Stress-Density Model Validation for Liquefaction Analysis

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Motivation

- Numerical modelling has become an increasingly valuable tool for liquefaction analyses in geotechnical research as well as industry rather than conducting centrifuge or full-scale tests.
- What are the capabilities/limitations of mathematical (constitutive) models used in these numerical modellings?
- How does a constitutive model which has been recently implemented in a widely used software (i.e., FLAC) work?
- Validation of the Stress-Density model [1,2] in FLAC is an attempt to fulfill the mentioned motivations.

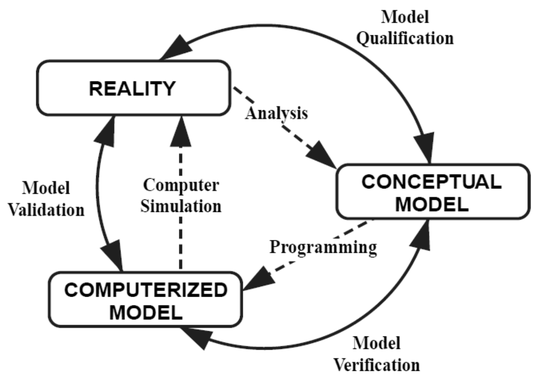

Figure 1: Modelling and the role of validation and verification [3]

Method

- Centrifuge tests can reproduce two characteristics which the behaviour of sand significantly depends on: 1) relative density, 2) in-situ confining stresses.
- Results of a well-conducted centrifuge test (~140 sensors, 55g in a 9 meters radius machine) is used for validation.
- Comparison between the centrifuge and 1D FLAC model was made for the free-field case.

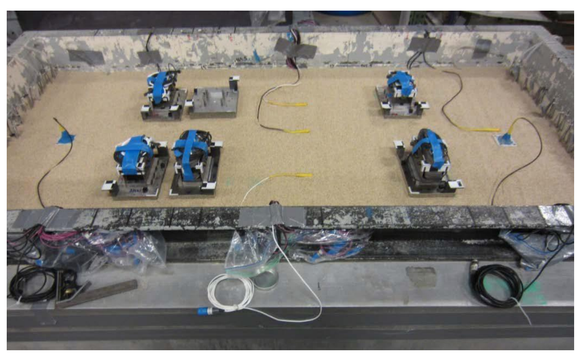

Figure 2: The surface of centrifuge model used in this study [4]

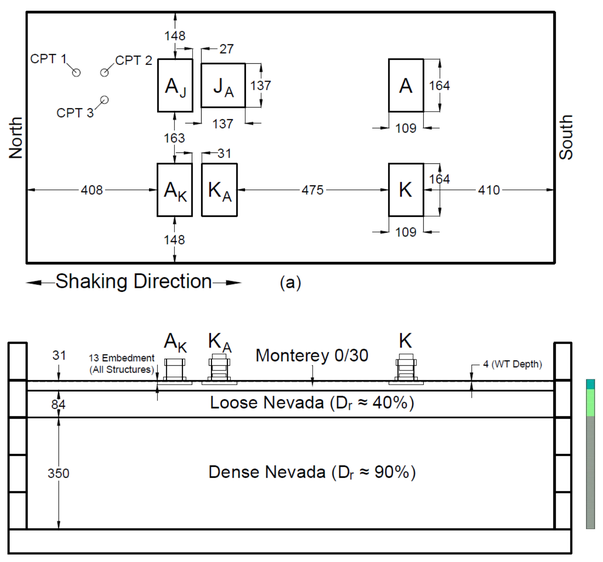

Figure 3: The elevation and plan view of the centrifuge model [4]

Preliminary Results

- Stress-Density model has three main parts. The parameters for sands used in the centrifuge test for two parts are introduced into FLAC. Preliminary results are promising, as sometimes models cannot even predict the overall trend of pore pressure generation or amplification of acceleration.
- Acceleration response is partially captured at the current stage.

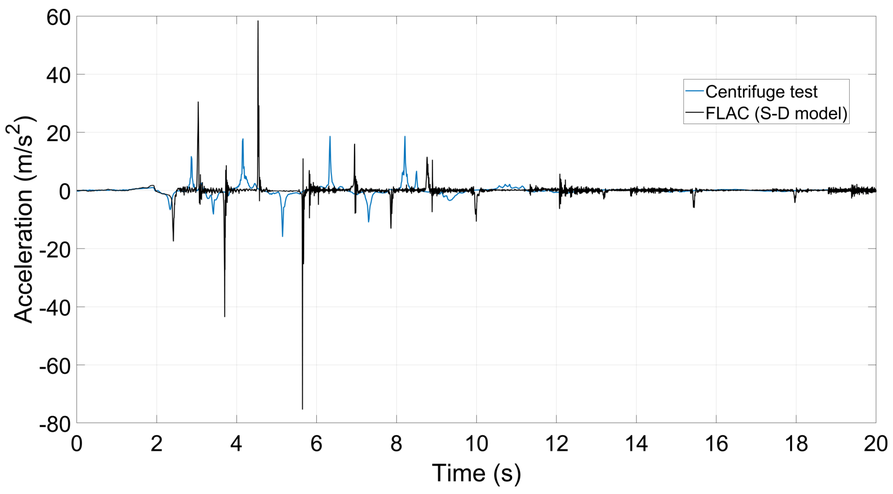

Figure 4: Acceleration response at the soil surface

- As Figure 4 shows amplification occurs in FLAC and centrifuge at the surface.

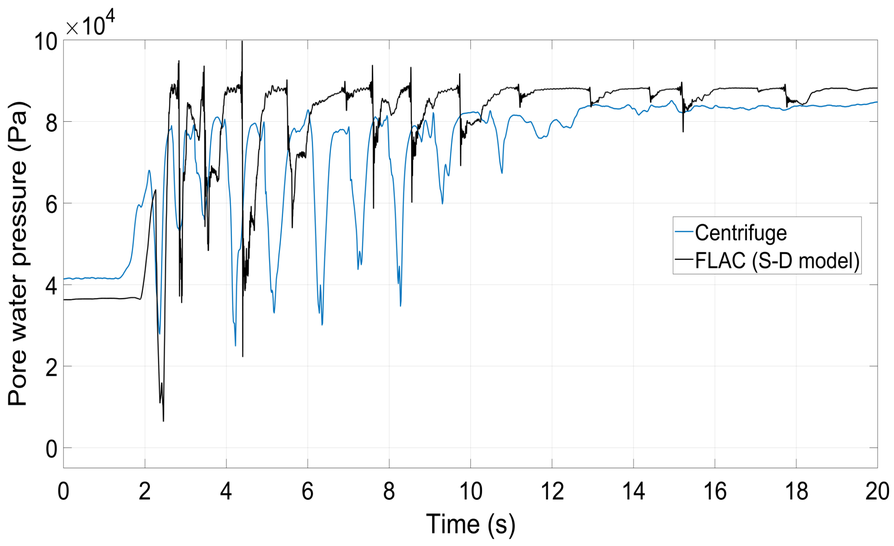

Figure 5: Pore water pressure at the middle of the loose layer

- Admitting the differences between FLAC and centrifuge results, the pore water pressure build-up pattern shows a good agreement in Figure 5
- Long-term simulations are still needed to compare the dissipation patterns.

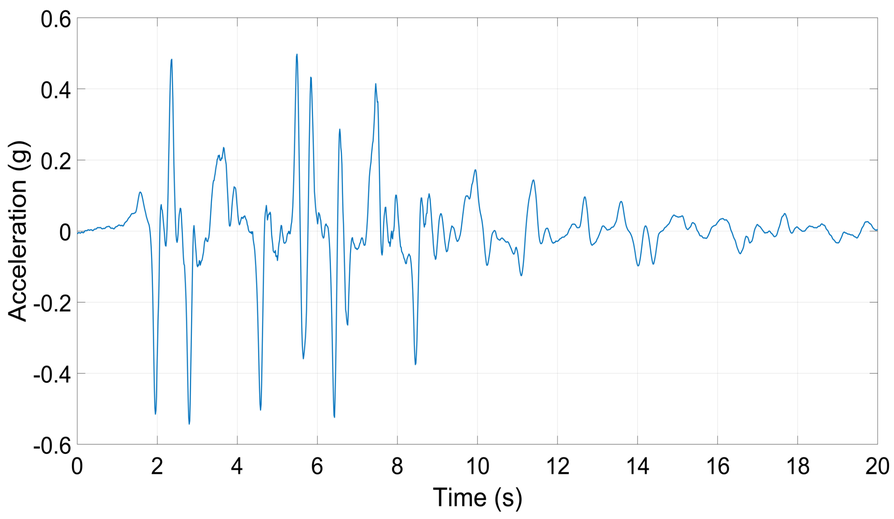

Figure 6: Ground motion applied at the base of the model

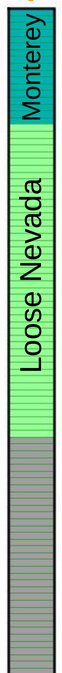

Figure 7: 1D free-field model in FLAC

Conclusion

- Preliminary validation of the Stress-Density model indicated that it can simulate pore water pressures and accelerations.
- According to the current stage of validation, potential uncertainties regarding the input parameters may have caused bias in predicting the acceleration response by model.
- Using other comprehensive experimental data (e.g., torsional simple shear test results) can enhance the accuracy of input parameters to FLAC, which in turn improves the Stress-Density model performance
- Further Validation with structures present in the model are required to evaluate the model in terms of the soil-structure interaction. This will be done in the near future.

References

[1] Cubrinovski, M. & Ishihara, K. 1998a. Modelling of Sand Behaviour Based on State Concept. *Soils and Foundations*, 38**,** 115-127.

[2] Cubrinovski, M. & Ishihara, K. 1998b. State Concept and Modified Elastoplasticity for Sand Modelling. *Soils and foundations*, 38**,** 213-225.

[3] Oberkampf, W. L., Trucano, T. G. & Hirsch, C. 2004. Verification, Validation, and Predictive Capability in Computational Engineering and Physics. *Applied Mechanics Reviews*, 57**,** 345-384.

[4] Hayden, C. P., Zupan, J. D., Bray, J. D., Allmond, J. D. & Kutter, B. L. 2014. Centrifuge Tests of Adjacent Mat-Supported Buildings Affected by Liquefaction. *Journal of Geotechnical and Geoenvironmental Engineering*, 141**,** 04014118.

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